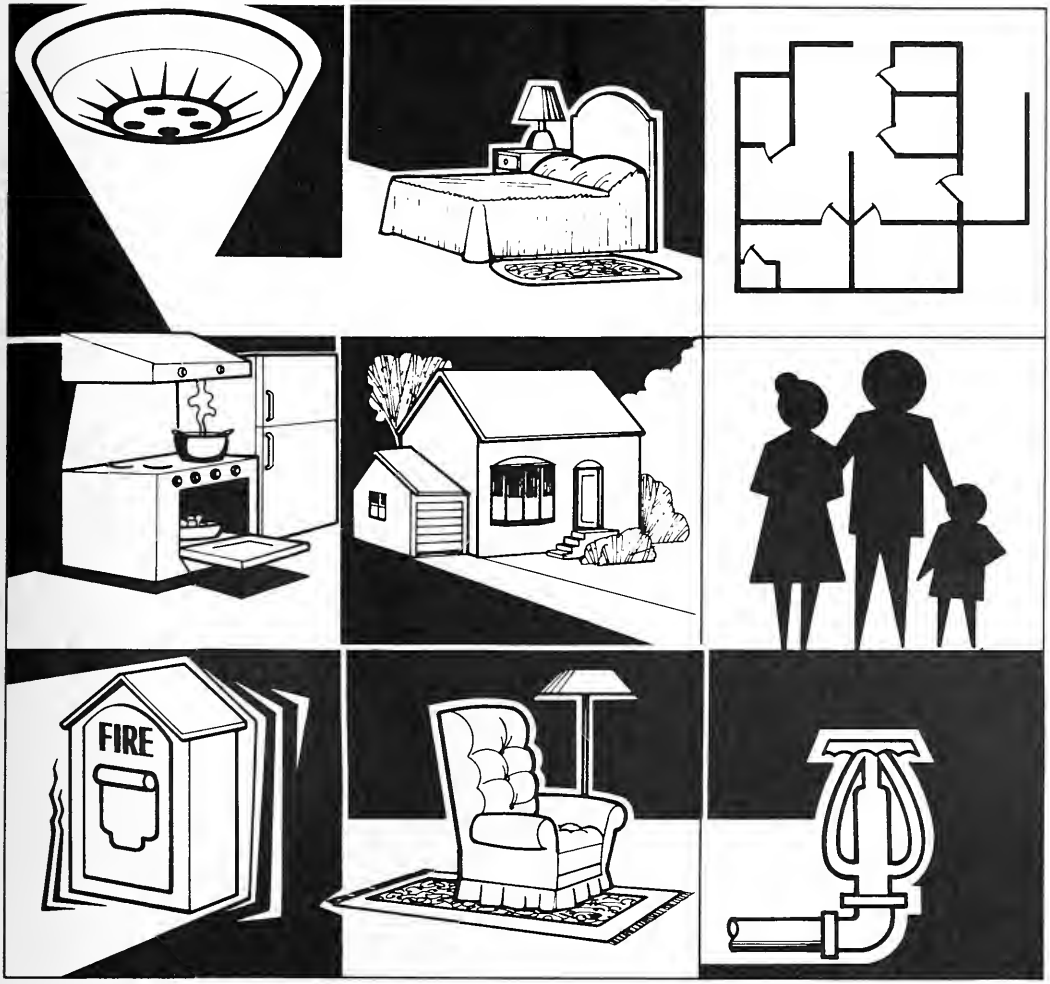

U.S. DEPARTMENT OF COMMERCE

National Fire Prevention and Control Administration

National Fire Safety and Research Office

Assessment of the Potential Impact of Fire Protection Systems on Actual Fire Incidents

Any opinions, findings, conclusions or recommendations expressed in this publication are those of the author(s) and do not necessarily reflect the views of the National Fire Prevention and Control Administration.

ASSESSMENT OF THE POTENTIAL IMPACT

OF FIRE PROTECTION SYSTEMS

ON ACTUAL FIRE INCIDENTS

Prepared for:

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I. SUMMARY

This study assessed the potential impact fire protection systems could have on the reduction of casualties (life loss and injuries) and property damage in residential fires. The assessment was based on the assumption that the fire protection systems would have been installed according to the minimum coverage standards proposed in the appropriate National Fire Protection Association codes. The area of the study is the State of Maryland and Washington, D. C.

Three separate fire protection systems were considered. These were a smoke detector system, a smoke detector system with the capability of automatic alarming to a fire alarm center (remote alarm system) and an automatic suppression system designed for residential use.

The fire protection system loss-reduction assessments were based on several assumptions. The two assumptions considered most important were:

(1) An operable fire protection system was correctly installed and maintained.

(2) The occupants reacted appropriately to a fire alert sounded by the system.

These assumptions provided common guidelines that allowed one to arrive at a reasonable approximation of an upper limit on the saving of life and the reduction of injuries and economic loss.

To arrive at the overall estimates, the basic data about the fire were obtained through on-site investigations by the Applied Physics Laboratory (APL) investigators and by interviews with the fire investigators of the appropriate jurisdictions. Other information and data about medical and toxicological consequences were obtained from the Maryland State Medical Examiner's Office. When the data was complete, a report on each case was written and submitted to the National Fire Prevention and Control Administration (NFPCA). The evaluation of "assessments of impact" was then made a three-man committee, examining and reviewing each case separately.

One hundred and seventeen fires were evaluated between June 15, 1976 and April 30, 1978. In the 117 fires there were 171 fatalities and 189 injuries. An estimated $2,813,000 property damage was inflicted. The casualties included civilians and firefighters. The dollar loss included only estimated property damage. No other economic factors such as hospital costs, time lost from work by the injured and loss of income by members of the household were included. In 68 percent of the fires at least one person survived.

The major scenario involved in the fatal fires was "smoking" in the bedroo and living room areas of the residences. In this scenario, people are not only involved as victims, but also as the initiators of many of the fires. Relaxation and sleeping areas in residences must be considered as primary targets in fire prevention and protection.

The major results of the study showed that 157 of the 171 fatalities could have been saved and 181 of the 189 injuries could have been prevented if the best of the three fire protection systems had been installed. The Suppression System would be somewhat more effective than the other two systems with 157 lives saved compared to 152 for the Remote Alarm System and 147 for the Detector (Only) System. However, these results assume all systems to be designed, installed, and maintained properly and all occupants responded correctly to an alarm.

The resultant total property damage was estimated to be minimum at $396,000 for the Suppression System compared to $675,000 for the Remote Alarm System and $912,000 for the Detector (Only) System. All of these are significantly below the estimated actual dollar loss of $2,813,000.

This means there might have been approximately a 90 percent reduction in both lives lost and injuries sustained if fire protection systems had been installed. Also, property loss would have been decreased by a factor of about 3 with the Detector System, by a factor of about 4 with the Remote Alarm System, and by a factor of about 7 with the Suppression System.

Behavior of occupants in a number of fires investigated showed that people were not fully aware of the serious life threat presented to them by a fire. The importance of educating the public to the total threat that a fire presents cannot be overemphasized.

Three typical case reports in Enclosures 1, 2 and 3 of this report exemplify the fire data collected, the scenario developed for the fire, the evaluation of the potential impact of the three fire protection systems, and the rationale on which the evaluation is based.

A detailed case report for each of the 117 fires evaluated in this study was forwarded to NFPCA as Appendix B of this report. The individual evaluation sheets assessing the effectiveness of the fire protection system in each case were included as Appendix A.

II. INTRODUCTION

A. Purpose of Study

This study assessed the potential value of fire protection systems in the reduction of casualties and property damage in residential fires. Data from investigation of actual fire incidents involving fatalities are analyzed to assess what the potential impact on deaths, injuries, and property damage would have been if a smoke detector system, a smoke detector system with a remote alarm capability, or an automatic suppression system had been installed in the residence.

B. Nature and Significance of Problem

Of all types of fires, residential fires are the major source of casualties and property losses in the United States. The goal of the National Fire Prevention and Control Administration (NFPCA) is to reduce this toll by 50% over the next generation (Ref. 1). One measure being recommended to achieve this goal is the increased installation of fire protection systems in reducing casualties and property damage in residential fires. This data would provide the NFPCA with a basis to use as guidelines in future programs that will aid in attaining their overall goals.

One approach for obtaining effectiveness data would be to install a large number of fire protection systems in residences located in representative geographical areas and accumulate case history data on their performance. This approach would require several years to implement and to analyze the data.

Another approach is to study the circumstances of actual residential fires where casualties have occurred and then make judgments on the potential effectiveness of the fire protection systems if they had been installed in the residence. The reliability of such an approach depends upon the thoroughness of the investigation of the fire incident and the soundness of the judgment made. Subjective biases could be minimized by comparing judgments of several fire investigators.

C. Scope

The scope of this report covers the investigation, evaluation and assessment of 117 fires from the study initiation date (June 15, 1976) through April 30, 1978. The primary emphasis is placed on life safety and property loss in residences as defined in NFPA No. 101-1976 - Life Safety Code.

The project was conceived to be an adjunct to the on-going National Bureau of Standards-funded APL Fire Casualty Study. All of the fires investigated had at least one fatality. The fires occurred in the State of Maryland and Washington, D.C.

D. Organization of This Report

This report contains a main body and two appendixes. The main body presents a summary, definition and results of the program with enclosed sample case reports.

Appendix A is a compilation of the evaluation tabulation sheets for each of the individual cases included in this report. These tabulation sheets present the actual results of each fire incident and the estimated results that might have resulted if a fire protection system had been installed.

Appendix B is in three parts. Each part contains a set of detailed case reports for each incident. Part I contains the first 25 cases, Part II contains cases 26-50 and Part III contains the remainder of the 71 cases.

E. Background

The Fire Problems Group of The Johns Hopkins University Applied Physics Laboratory has been investigating fires that have resulted in fatalities in the State of Maryland as an on-going program since September 1971 (Ref. 2). This involves a thorough investigation into the physical fire scene as well as the detailed pathological, toxicological, biochemical and medical aspects relating to the mechanisms involved in a fatal fire.

The fatality study is a cooperative effort of the Maryland State Fire Marshal and his staff, the Chief Medical Examiner for the State of Maryland and his staff, and local fire investigative staff of Baltimore City, the District of Columbia and counties of Maryland. The program has six major functional areas of participation. The functional areas and the organizational participation are:

1. Program Coordination -- APL/JHU has the primary responsibility of coordinating the study.

2. Post-Mortem Analyses -- The Maryland State Medical Examiner provides detailed pathological and toxicological analyses of fire fatalities. This includes carboxyhemoglobin and blood alcohol levels as well as possible drug involvement. As a result of a special blood cyanide study, accurate and meaningful post-mortem blood cyanide levels are now being measured. Heart condition is given careful scrutiny in order to evaluate possible carbon monoxide -- heart disease interactions.

3. Field Investigations -- The Maryland State Fire Marshal and his staff, and Baltimore City/County fire investigators provide routine reports on physical aspects of the fires and the demographic information about the victims. An APL fire investigator visits the scene in an attempt to obtain samples of materials that were involved in the fire, soot samples, and the data provided by the fire department investigators.

4. Biochemical and Chemical Analyses -- Analyses are made by APL and the National Bureau of Standards on biological and other samples obtained during the autopsy and at the fire scene. Tracheobronchial tree scrapings for metal analysis, fire-involved materials, and soot are analyzed.

5. Medical Analyses -- When the post-mortem and biochemical data are available, a medical group analyzes them. A judgment is made about the cause of death and, if possible, a reason is given why escape did not take place. The Medical Examiner and his staff provide these functions.

6. Data Analyses -- All data for each case are analyzed to correlate physical, medical, and other findings. At this time, conclusions about fire fatalities can be drawn that may aid in understanding the conditions and allow suggestions of practical solutions. The entire group is responsible in this area with most of the effort centered at APL.

Based on this operational framework for investigations, it was decided to attempt to assess the impact on the outcome of residential fires if a fire protection system (FPS) had been installed. The National Fire Prevention and Control Administration (NFPCA) provided a grant to undertake such a study. Work was begun on June 15, 1976.

When a person dies as a result of a fire, it is difficult to reconstruct causes and consequences in detail. To understand the problem requires a thorough investigation to gather physical data about the fire (to characterize the fire environment), to define the medical consequences, and to review and analyze relevant evidence in an attempt to understand the individual pathways resulting in the death of a victim (physical, clinical, pathological, etc.).

The initial investigation of the fire scene is provided by the staff of the Maryland State Fire Marshal, Baltimore City, Washington, D.C., or local county investigators depending on who has the jurisdictional assignments. The APL investigators visit the scene 1 or 2 days after the event, and they usually are accompanied by the original investigators. The investigators provide information about the fire events such as time elements, human involvement, ignition source, first items of ignition, spread factors, materials involved, building information and exit capability. The resulting information aids in defining the events of the fire situation, in interpretation of the data and provides some insight into how the final outcome of the fire resulted.

At the beginning of this study, a decision had to be made whether all possible scenarios should be considered in the assessment. A decision was made to consider the fire protection systems to be operating under optimal conditions within the fire events as investigated. Thus, the evaluations will provide a measure of the maximum effectiveness that the fire protection systems

could provide under the fire conditions that prevailed. Throughout this report the end result of the assessment will be called the "upper bound" for the effectiveness of a system. The set of interpretations providing the best results possible furnish a common base for discussion and future modeling.

NOTE: Autopsies are performed in the State of Maryland at the discretion of the attending deputy medical examiner. As a result, a small number of the Maryland cases were not autopsied. Autopsy results for Washington, D. C. cases were not available.

III. DESCRIPTION OF STUDY

A. Investigation of Fires

When there is a fire in Maryland or Washington, D. C., in which a death occurs, the Johns Hopkins University Applied Physics Laboratory investigation team is notified by phone of the incident. At that time pertinent data about the fire is obtained.

The APL team investigates the scene of the fire, usually accompanied by the fire investigators of the jurisdiction involved. The primary investigators are members of the State Fire Marshal's staff or city or county investigation bureaus. The investigation is made to determine such items as ignition source, first item ignited, spread factors, time elements, human involvement, building information, exit capability, and materials involved in the fire. Photographs are taken, interviews are conducted whenever possible, sketches of room arrangements and exit paths in the dwelling are made, and the sequence of events in the fire are recorded by the investigators. The data and information obtained are recorded as part of the case history of the incident to be used later in the analysis and evaluation phase. Data and information of the pathological and toxicological results are obtained from the Medical Examiner's office to include in the overall report and assessment.

A report is written to document the incident.

B. Levels of Protection for Assessment

Three different fire protection systems are considered in this study. The first system is a smoke detector system that passes the UL criteria and is installed according to NFPA standards (Ref. 3) and guidelines set by the National Bureau of Standards (NBS) (Ref. 5). The second system is an automatic suppression system with a quick-reaction feature plus an internal alarm capability using water as the agent. The third system is the above smoke detector system provided with remote alarm capability to a fire alarm center.

Some of the important features of each system are summarized below:

1. With the detector-only system, a minimum number of detectors are assumed to be properly installed in accordance with the guidelines set down in Code NFPA 74-1. The lowest level of protection is provided if one smoke detector is located outside each sleeping area in the residence. In a few cases the manner in which the residence is either constructed or used might cause a variation not necessarily covered in the code. When this occurs, the APL investigators assume the detector location that they believe will provide maximum safety within the basic guidelines on NFPA 74-1.

2. The automatic suppression system is assumed to be designed for residential protection with a quick-reaction feature and an audible alarm to alert occupants. The system is assumed to be installed throughout the residence in accordance with NFPA Standard 13D. During the evaluation phase of this

study, a further assumption is made that the system is capable of either completely extinguishing the fire or controlling and preventing spread of the fire until the fire department arrives on the scene.

3. Remote-alarm capability in this study has been considered only with the smoke detector system, but that does not preclude the same capability with a suppression system. In this system the fire alarm center is automatically notified as soon as the detector is activated in the residence.

C. Major Assumptions

It is well known that humans can react unpredictably under stress circumstances, including a fire. Many of the people in the cases studied showed signs of being unaware of the magnitude of the fire problem in regard to their safety. Some people question the reliability of an ionization-type smoke detector. Others question whether a sprinkler system will activate before the victims are incapacitated by toxic combustion products. The question of appropriate maintenance of smoke detectors (battery replacement, cleaning, etc.) is also valid.

Considering all possible variations of human behavior in the fire situation and variations in the electronic and mechanical performance of fire protection systems could lead to a different evaluation for each of many scenarios for a particular fire incident. In view of this, it was decided to attempt to determine an "upper bound" to the potential effectiveness of the fire protection system. To do this APL made two basic assumptions in assessing the impact of a fire protection system if it had been installed in the case under consideration:

1. An operable fire protection system is properly installed and maintained.

2. The occupants will react properly to the fire alert, that is, get out of the building and sound the alarm from places outside the burning structure.

The first assumption implies that the fire protection system will alert the occupants before smoke density, toxic gas concentrations, and temperatures reach critical levels for untenability. The second assumption implies that the occupants will react to the alarm and evacuate the building. It is assumed that, once outside, the occupants will send in an alarm to the fire department from the nearest alarm box or telephone, not in the residence on fire. The use of these two assumptions provides a common baseline for evaluating all the fire incidents.

D. Assessing Impact of a Fire Protection System

The initial step in the assessment is to obtain information on the actual losses. The fatality and injury count is normally a simple procedure since fire department investigators routinely log this information in their

records. When serious injuries have resulted from the fire, follow-up is necessary to determine whether the injuries led to a delayed death, resulting in more fatalities for the case.

Obtaining estimates of property damage to buildings and contents is more difficult. Some fire investigators are capable of providing a reasonably accurate estimate of the dollar amount of the loss. Other investigators prefer to wait for estimates provided by insurance companies but these data are not readily available. The APL team of investigators also makes an estimate of the actual loss. The loss reported for each case of this study is recorded after a careful evaluation of all sources (see Appendix A).

In the APL estimate the location of the residence, the type of construction, the size of the building, and the arrangement of rooms are all considered. The area damaged by the fire is estimated and a replacement cost factor in dollars per square foot is applied to estimate the total fire damage to the building. The cost factor being used ranges from $25 per square foot for simple design houses to $45 per square foot for luxury type homes. In estimating fire damage to contents, current replacement costs for items of comparable quality are used.

Taking into consideration the opinion of state and local fire investigators handling the case regarding the impact a fire protection system would have had in the fire incident, the APL investigators review the circumstances of each individual case. Major considerations are time estimates for fire spread, fire protection system activation, and reaction of the occupants to the fire danger. After thorough discussion of the possible outcomes in the incident, a consensus judgment is made by the three-member APL investigation team in regard to the impact the fire protection system would have had in the outcome of the fire. The assessment for each system is performed on a mutually exclusive basis, that is, an estimate is made for the protection system by itself without considering the possible influence that can be introduced by the additive effect of another type of system.

Three typical case reports in Enclosures 1, 2 and 3 exemplify the fire data collected, the scenario developed for the fire, the evaluation of the potential impact of the three fire protection systems, the rationale on which the evaluation is based, and the evaluation sheets on which are entered the APL estimates of the impact the fire protection systems would have on casualties and property damage in the fire.

Case reports for all 117 fires investigated in this study are available from the National Technical Information Service (NTIS) as Appendix B of this report.

National Technical Information Service
U. S. Department of Commerce
5285 Port Royal Road
Springfield, VA 22161

IV. CASE DATA

During the period June 15, 1976 through April 30, 1978, 117 fatal fires were evaluated for the study. There were 92 fires in Maryland and 25 in the District of Columbia. A total of 360 casualties resulted from those fires, including 171 fatalities. Of the 171 fatalities, 136 were in Maryland and 35 in the District of Columbia. Of the 360 casualties, 54 were firefighters and two of these were fatalities.

The number of fires in which there were survivors totaled 64 in Maryland and 16 in the District of Columbia. Thus, in 68 percent of the fires at least one person survived or escaped the fire. In a number of the incidents the escapees also aided others in their escape.

Data on the source of ignition are obtained from fire investigators from the jurisdiction involved. Their presence at the fire scene affords the best opportunity to accurately determine such data. The ignition source and room or origin of fatal fires are shown in Tables 1 and 2. Careless use of smoking materials is by far the principal cause of the fatal fires accounting for almost one half of the total. Also noteworthy is the large percentage (over 60 percent) of the fires caused by human error as indicated by the combined smoking, matches, and cooking categories. The human element, although not always obvious, is also reflected in careless use of flammable liquids and the category labeled "other". The distribution of fires according to cause is consistent with the larger data base obtained in the overall APL Fire Fatality Program (Ref. 2). It should be noted that the distribution of fatal fires according to source of ignition differs from the corresponding distribution for all fires (fatal and non-fatal) primarily in the number of fires in the "smoking" category. Careless use of smoking materials is the source of ignition for half of the fatal fires whereas in all fires not individual source of ignition predominates. Data on the distribution of all fires according to source of ignition is given in Ref. 4.

TABLE 1

DISTRIBUTION OF FIRES ACCORDING TO CAUSE*
STATE OF MARYLAND AND DISTRICT OF COLUMBIA
June 15, 1976 - April 30, 1978

Cause	Number of Fires	Percent
Smoking	53	45
Matches	9	8
Flammable Liquids	2	2
Heating Equipment	20	17
Electrical	17	14
Cooking	6	5
Other	8	7
Unknown	2	2
T O T A L	117	100

*These data are in agreement with the data obtained during the previous five years of the JHU/APL Fire Fatality Study. Through correspondence with Mr. John Ottoson we determined that the data is in agreement with the NFPCA forthcoming report on "National Estimates".

TABLE 2

DISTRIBUTION OF FIRES ACCORDING TO ROOM OF ORIGIN
STATE OF MARYLAND AND DISTRICT OF COLUMBIA
June 15, 1976 - April 30, 1978

Room of Origin	Number of Fires	Percent
Living Room	31	27
Bedroom	45	38
Kitchen	21	18
Living/Bedroom*	5	4
Other	15	13
T O T A L	117	100

*This designation refers to efficiency type apartments.

The distribution of fatal fires according to room of origin is presented in Table 2. The listing reflects the principal cause of fires in that the bedroom and living room are the areas in the residence where careless smoking would most likely occur. In two-thirds of the bedroom fires, careless smoking was the suspected cause of the fire. The kitchen is frequently the room of origin in non-fatal fires but much less frequently in fatal fires. The fatal fire originating in the kitchen is usually the result of cooking food left unattended or clothing ignited by the stove.

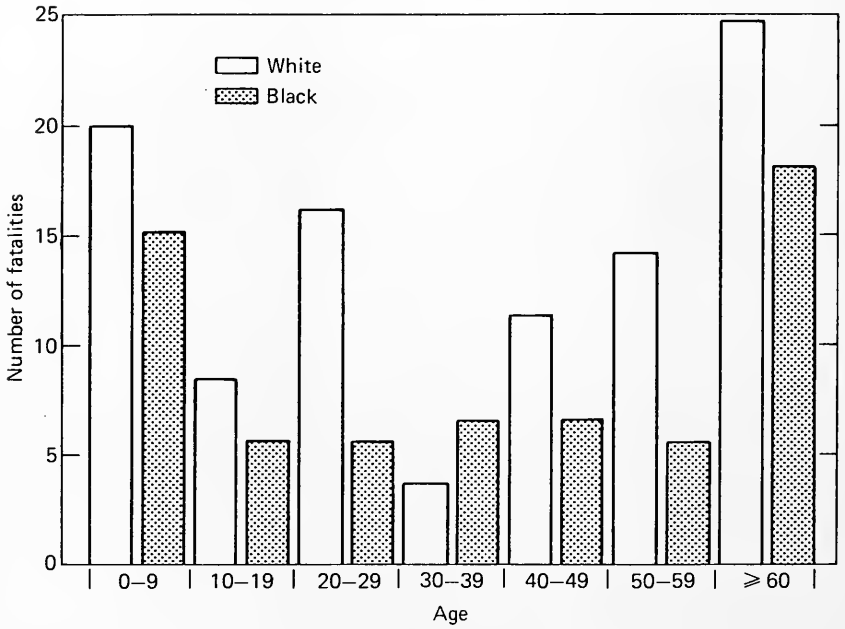
The data on age, sex and race for the fatal fires covered in this report are shown in Figs. 1 and 2 and in Table 3. The data represents actual fatalities and are not adjusted or normalized to population data. The data on race can be grossly adjusted for population differences by noting that the combined population of Maryland and the District of Columbia is approximately 73 percent white and 27 percent black. The number of black fatalities is 39 percent of the total which is somewhat larger than the percentage of black population.

The general distribution of fire fatalities as a function of age (Fig. 1) shows the greater mortality rate among children and the elderly, which is consistent with previous data obtained in the APL Fire Fatalities Study (Ref. 2). This previous study has shown the ratio of male to female fire victims to be approximately two to one, which is also evident in the present data for white victims. For black victims the greater number of female victims is unusual, and no explanation is readily apparent. It is interesting to note that the number of black female victims is greater in almost all age groups.

DISTRIBUTION OF FIRE FATALITIES ACCORDING TO AGE AND RACE

STATE OF MARYLAND AND DISTRICT OF COLUMBIA

June 15, 1976 - April 30, 1978



NOTE: The population of the State of Maryland and District of Columbia combined is approximately 26.5% Black and 73.5% White (1970).

DISTRIBUTION OF FIRE FATALITIES ACCORDING TO AGE AND SEX

STATE OF MARYLAND AND DISTRICT OF COLUMBIA

June 15, 1976 - April 30, 1978

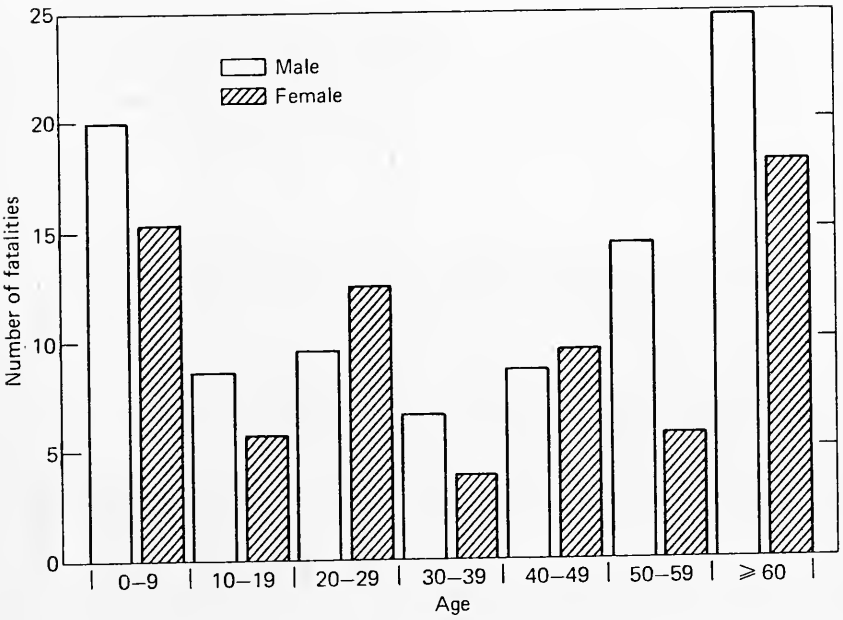


TABLE 3

DISTRIBUTION OF FIRE FATALITIES ACCORDING

TO AGE, SEX AND RACE

STATE OF MARYLAND AND DISTRICT OF COLUMBIA

June 15, 1976 - April 30, 1978

	WHITE		BLACK	
Age	Male	Female	Male	Female
0-9	15	6	6	10
10-19	7	2	2	4
20-29	9	8	1	5
30-39	3	1	4	3
40-49	5	7	4	3
50-59	11	4	4	2
over 60	16	10	10	9
TOTAL	66	38	31	36

V. RESULTS AND EVALUATION

A. Results

The overall results of APL's estimate of the potential impact of three types of fire protection systems on casualties and fire damage in the 117 fires investigated are presented in Tables 4 and 5, respectively. The results for individual fire incidents are given in Appendix A.

In the 117 fires investigated there were 171 fatalities, two of the fatalities being firefighters. There were 189 persons injured in those fires, including 52 firefighters.

The total fire damage was estimated to be $2,813,000 of which $2,165,000 was damage to the building and $648,000 was damage to the contents. The dollar less includes only estimated property damage and no other economic factors were considered such as hospital costs, time lost from work by the injured, and loss of income by members of the household.

B. Evaluation

(a) Casualties

Based on the assumptions used as guidelines in assessing the potential impact of a fire protection system, 157 of the 171 fatalities could possibly have been saved and 181 of the 189 injuries could possibly have been prevented.

The results indicate that the Suppression System would be most effective in regard to "definite saves" with 143 of the 171 fatalities being saved, compared to 131 saves for the Remote Alarm Detector System and 122 for the Detector Only System. If the "probable saves" are added to these numbers, the results show that the Suppression System would be somewhat more effective than the other two systems with 157 "probably saves" compared to 152 for the Remote Alarm System and 147 for the Detector Only System.

In regard to injuries, the results also indicate that the Suppression System would be somewhat more effective in preventing fire-related injuries with 181 "probably saves" compared to 172 for the Remote Alarm System and 166 for the Detector Only System.

(b) Property Damage

The resultant total property damage with a fire protection system installed was estimated to be minimum at $396,000 for the Suppression System compared to $675,000 for the Remote Alarm System and $912,000 for the Detector Only System. All of these are significantly below the estimated actual dollar loss of $2,813,000.

TABLE 4

ESTIMATE OF FIRE PROTECTION SYTEMS' IMPACT
117 FIRES WITH AT LEAST 1 FATALITY

June 15, 1976 - April 30, 1978

Fire Information			Predicted Results with Installed Fire Protection System			
		Actual		Detector System ① ②	Suppression System ①	Remote Alarm System ① ③
Casualties	Deaths	171	Saved	122	143	131
			Prob. Saved	25	14	21
			No	24	13	15
	Injuries	189	Saved	151	170	161
			Prob. Saved	15	11	11
			No	23	8	16

① Assumes proper occupant reaction and an effective system.

② The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

③ One death on boat - removed from count since remote alarm system not applicable.

NOTES:

(1) In one case (FPS-87), a suppression system was not considered for the residence since there was no water, electric, or telephone service to the involved residence. There was 1 death and no injury in that case.

(2) In 4 cases (FPS-64, 87, 93 and 114), a remote alarm system was not considered since there was no telephone service to the involved residence. There were 4 deaths and 1 injury in those cases.

TABLE 5

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT
117 FIRES WITH AT LEAST 1 FATALITY
June 15, 1976 - April 30, 1978

Fire Information			Predicted Losses with Installed Fire Protection System		
		Actual	Detector System ① ② ③	Suppression System ①	Remote Alarm System ①
Property Loss (Thousands) (of Dollars)	Building	2165	704	280	513
	Contents	648	208	116	162
	Total	2813	912	396	675

① Assumes proper occupant reaction and an effective system.

② The numbers shown are based upon the presence of an occupant. Without an occupant, the losses will be greater.

③ The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested.

VI. DISCUSSION

A. Baseline for Evaluation

At the beginning of this study a decision had to be made whether all possible scenarios would be considered in the evaluation of the potential effectiveness of a fire protection system in an actual fire incident. Considering all possible variations of human behavior in the fire situation and variations in the electronic and mechanical performance of fire protection systems could lead to a different evaluation for each of many scenarios for a particular fire incident. In view of this, a decision was made to attempt to determine an estimate of the highest values for the potential effectiveness of the fire protection system. We have called this estimate of the highest values the "upper bound." The evaluations made in this study were based on the two major assumptions listed in the previous "Description of Study" (Section III.C.). This provided the APL team with a common baseline for evaluating each case. The "upper bound" is considered to be useful for people reviewing the data because they can have a base value to work with in their analyses if they wish to apply variations in the scenario.

B. Difference between Detector and Remote Alarm Systems

The three fire protection systems evaluated in this study were the Detector System, the Suppression System, and the Remote Alarm System. In evaluating the effectiveness of the systems, the primary difference between the Detector System and the Remote Alarm System is the assumed time difference between activation of the detector alarm and receipt of the alarm for dispatch at the fire alarm center. The two systems are identical expect that with the Detector System, sending the alarm to the fire department requires appropriate action by humans, whereas with the Remote Alarm System the alarm is transmitted automatically. The estimated time that would be required for the alerted occupants to escape from the burning residence and then sound the alarm to the fire department either from a fire alarm box or by telephone outside the involved residence accounts for the differences that show up in the evaluations of the two systems. Depending upon the circumstances involved in the incident the time delay could vary from approximately 3 minutes to 15 minutes or more. Again, each individual case must be evaluated separately.

C. Fatal Fires with Fire Protection System Installed

Of the 117 fires investigated there were twelve fires which involved fire protection systems. All twelve fires involved smoke detectors (nine ionization, two photoelectric and one system used a heat-sensing detector). One of the twelve fires involved rate-of-rise heat detectors. In two of the fires the system included an automatic internal alarm connected to monitoring panels in the residences. One system also had a remote-alarm capability into the local fire department. There was at least one fatality in each of the twelve fires. These cases are examples showing that events can go wrong in residences protected by detection systems. However, in eight of the cases, the problem appeared to be a human error rather than a system malfunction. In fact in six of the fires the

fire protection systems were instrumental in alerting occupants, resulting in the saving of lives. A brief synopsis of the twelve incidents follows to highlight the factors that affected the outcome of the cases. Complete details are given in the case reports in Appendix B of this report.

Case 1: The occupant had purchased a smoke detector but failed to install it. It was still in its original carton at the time of the fire. There was one death in this fire. Although the fire was confined to the kitchen and self-extinguished there, the house was filled with smoke which led to the death of the occupant from asphyxiation by carbon monoxide poisoning. The APL investigators concluded that the detector would have saved the life if it had been installed.

Case 2: The residence involved in this fire had four apartments, each of which had an ionization type-smoke detector installed. The apartment of origin had the detector improperly installed on the bedroom ceiling close to the corner of the room. The fire originated in the opposite end of the apartment in a den where the lone occupant was sleeping. He was alerted to the fire but apparently not by the detector. He walked the full length of the apartment, passing an exit on the way, and was overcome in a bathroom just off the bedroom. He waited too long to make his escape and became a fatality. The detectors in two other occupied apartments did activate and their occupants successfully escaped without injury. Proper escape action on the victim's part would have resulted in no deaths in this fire.

Case 3: The fire originated in an enclosed porch off the living room. A man and his wife were asleep in a bedroom at the opposite side of the house. An ionization-type smoke detector mounted in the hallway outside the bedroom sounded its alarm and awakened the occupants. In response to the alarm, the man and woman escaped to the outside. The man reentered the house to telephone the fire department but was overcome there, dying from asphyxiation by carbon monoxide poisoning. The wife was saved. Proper action on the man's part, namely, not reentering the house but telephoning the alarm from a neighbor's home, would have resulted in no fatalities in this incident.

Case 4: An ionization-type smoke detector was installed outside the bedroom on the third floor of the involved house. For minimum coverage, a second detector should have been installed outside the bedrooms on the second floor but was not. A

flash-type fire occurred in the night clothes of a man using a second floor bathroom whose door was closed and resulted in his death. In view of the nature of the fire, it was concluded that detectors could not have save the life of the victim. However, the installed detector did activate soon after the fire started and would have alerted three other occupants of the house if they had been asleep.

Case 5: During the night a fire started in the sofa in the living room of a third floor apartment in a large apartment complex. An ionization-type smoke detector located in the hallway outside the bedrooms alarmed at about 4 AM, alerting the family of five to the fire danger. The family apparently milled about trying to decide what to do. When they finally attempted to escape their main exit was blocked by the fire. Four people jumped to safety, but one person delayed his escape and died in the fire from asphyxiation by carbon monoxide poisoning. APL investigators concluded that quick, proper action by the family would have resulted in all of them escaping.

Case 6: This fire started at about 5:30 PM in a man's bed from careless use of smoking material. The man carried the burning bed clothes to a bathroom across the hall and attempted to extinguish the fire but was unsuccessful. By the time that a first floor occupant became aware of the fire when she smelled smoke it was too late to rescue the man and he died as a result of the fire. One smoke detector in the second floor hallway outside the bedrooms would have provided a minimum coverage detector system. APL investigators concluded that the detector would have been instrumental in saving the man's life.

Actually, an ionization detector was installed in this residence but the battery was dead. The occupants were aware of the dead battery. They had a low-voltage warning from the device and had received a notice from the manufacturer to replace the battery. The detector was mounted in the first floor entrance hall and thus did not meet minimum coverage specifications which would require a detector outside the second floor sleeping area.

Case 7: This was a hotel fire originating in a first floor laundry room. The hotel had a fire protection system which included ionization detectors on all floors and rate-of-rise heat detectors in the laundry room. The detectors were connected to an internal alarm system and a panel at the front desk which apparently was not manned when the fire broke out. The detectors were activated and the alarm sounded throughout the hotel. Occupants of the hotel reported that they heard the alarm, some initiating escape immediately; others thinking the bell was the elevator alarm, delayed their escape. Others

reported that they did not even hear the alarm. At least 70 people escaped from the burning hotel, but three people died in this fire. Considering the circumstances and time elements involved, APL investigators concluded that the three victims could have survived with quick and proper reaction to the internal alarm.

Case 8: This fire occurred in a residence which the owner had partially converted into a "domiciliary care" type nursing home. The basement area where the patients rooms were located was protected with a fire protection system which included a photoelectric smoke detector in each of the patients rooms, an internal fire alarm connected to a monitoring panel and a remote alarm system into the fire alarm center. There was also an ionization type smoke detector installed in the owner's first floor bedroom area but this unit was not connected to the basement fire protection system. The fire protection system and the separate smoke detector did activate and the internal and remote alarms did function properly. The fire protection system was instrumental in the survival of 8 occupants of the home but one of the patients died in the fire in the room of origin.

Case 9: On the day of this fire seven people were in the involved house, an old, three-story brick, row house. A woman sleeping in the living room was awakened by the alarm from an ionization-type smoke detector mounted in an adjacent hall. She found a fire in the corner of the room. The woman alerted the other occupants by calling out "Fire". All of the occupants except one escaped through the kitchen door. The female victim was found in a third floor, front bedroom which was damaged only by smoke. The victim probably was alerted either by the alarm of the smoke detector or the cry of "Fire". She probably tried unsuccessfully to escape through the fire advancing up the stairway and then retreated to her third floor bedroom where she was overcome by smoke. If she had responded promptly and properly to the alarm, APL investigators concluded the victim would have survived. There were several emergency exits available on the two floors above the fire floor for the victim to escape.

Case 10: This fire occurred in an old, single-story, wood frame motel unit that was rented to permanent residents. The unit was equipped with a heat sensing detector which was monitored at an annunciator panel in the motel office. There was no internal fire alarm in any of the units. According to the person monitoring the panel, the fire detection system did not alarm during this incident. APL investigators would propose

a smoke detector equipped with an internal alarm in the unit rather than a heat detector. Even with a smoke detector in the involved unit, it was APL's judgment that the detector would not have been effective in saving the lives of the 2 and 3 year old victims. Children that young cannot be expected to act appropriately in response to the detector alarm.

Case 11: This fire which started in the kitchen of a two-story townhouse resulted in two fatalities. Both victims had escaped safely but reentered and were trapped by the advancing fire which eventually killed them. As firefighters attacked the fire, they heard a fire detector alarming in the house. They traced the alarm to a photoelectric-type smoke detector still in its box on a lower shelf of a bookcase in the living room. Batteries had been installed in the detector, making it operable. In evaluating the case, APL investigators concluded that, if the detector had been installed in the proper location, it would have provided sufficient early warning for all the occupants to escape.

Case 12: This fire occurred in a two-story, brick, row house in a large city. A smoke detector (ionization-type) energized by 115 volt house power was located on the ceiling of the first floor hall. The room of origin was a bedroom just off that hall. The source of ignition was an electrical malfunction in a television set which the victim was watching. Power went off in the house when the fire started. None of the survivors reported hearing the detector alarm at any time during the incident. The fact that the electricity went off probably was a factor in its failur to alarm. In view of the time factor which appeared to be involved, even an operable detector would not have given sufficient early warning in this case for the victim to escape. The fire apparently started in the flaming stage and spread rapidly in the room of origin, trapping the victim there.

D. Specific Data for No Saves

The results in Table 4 indicate that about 10% of the fatalities that occurred in the fires investigated could not have been saved. The types of fires in which the fatality would not have been saved with the Detector System were:

Type	No. of Fatalities
Flash fire	9
Highly intoxicated victim resisted rescue attempt	2
Victims were invalids	2
Delayed alarm to provide aid to elderly patient	1
Very young children unattended	5
Fire resulted from gas explosion in residence	2
Human behavior (Fear of attack by arsonist affected behavior of victim in escape attempt)	2
Transient in an unprotected area of an apartment building	1
	24

The summary in Table 4 for the Remote Alarm System indicates there would be 9 fewer fatalities than with the Detector System. The consensus of the APL investigating team was that, considering the time elements in the cases, the Remote Alarm System would have brought the fire department to the scene soon enough to rescue the 9 victims before they were overcome.

Table 4 also shows that in 11 incidents there would have been a net saving of 11 lives with the Suppression System compared to the Detector System. In two cases, where the fire was limited in intensity, a smoke detector probably would have alarmed early enough for the victim to escape. However, with only a Suppression System installed, the victim probably would have been overcome by smoke by the time that the fire was intense enough to trigger the Suppression System. In the 9 other cases where smoke detectors would not have alarmed soon enough, usually because of the rapid spread of the fire, the Suppression System would have become activated early enough to control the fire before toxic combustion products built up to lethal levels.

E. Adjusting the "Optimum Effectiveness" Results

As previously emphasized the estimates of the effectiveness of fire protection systems reported herein are the best results that is believed can be expected with the systems. In the real-life situation of an actual fire incident one can expect less than optimum performance for various reasons.

For life safety, the element of human behavior will play an important part in the effectiveness of all three systems. The basic rule that should be followed is that the occupants immediately evacuate the involved residence at the first alarm from the smoke detector or the activated suppression system. The investigations made in this study demonstrate that some occupants of a burning residence will not always act properly for their own safety (Ref. Enclosure 1). Yet, other cases covered in this study show that where fire protection systems were installed occupants do react properly, resulting in the saving of life (Ref. Enclosure 3). Thus, it is very apparent that the public must be educated to react to the danger presented by the fire environment to ensure life safety. This includes the concept of early evacuation upon receiving an alarm from a fire protection system.

Differences in performance characteristics of the systems can have an effect on the outcome of the fire. If the sensitivity of the equipment changes for whatever reasons, the amount of time to react may change significantly. If high false alarm rates are present the humans will tend to disregard the alarm or possibly disable the device resulting in serious problems. There is probably an extensive list of "ifs" but until they are clearly defined in a quantitative manner no degradation of the results for this study are considered.

Human behavior and differences in time elements for the three systems considered in this study can affect the property damage resulting from the fire. No action on the part of humans is necessary to alarm the fire department

with the Remote Alarm System, but such action is necessary with both the Detector (Only) System and the Suppression System. The present Suppression System concept visualizes that the system would be designed to control the fire until the fire department arrives rather than to extinguish the fire completely. Typical times after the alarm is received for dispatch for the fire department to arrive at the scene would be 3 minutes for urban fires and 6 minutes for rural fires. Variations in response times will affect property damage in fires.

The study reported herein does not provide sufficient basis for adjusting the "upper bound" results to predict the outcome of future real-life fire incidents. Obtaining the statistics to do this could be the objective of a future study.

VII. CONCLUSIONS

Based on the assumptions and evaluations of the 117 fires investigated in this time period, the installation of any of the fire protection systems would have had a significant effect on the overall outcome of the fires investigated. Indications are that up to 90% of the casualties might have been eliminated. The results also indicate that property loss might have been reduced by 68% with the Detector System, by 76% with the Remote Alarm System, and by 86% with the Suppression System.

Behavior of occupants in a number of the fires investigated shows that humans do not seem to be fully aware of the serious life threat presented by a fire. They seem to believe that only the flames are dangerous and not the smoke. They also are obviously unaware of the rate at which a fire can spread. The importance of educating the public to the total threat that a fire presents cannot be overemphasized.

The results summarized in Table 6 - Data on Room of Origin/Mobility indicates 95% of the fatalities excluding the touch deaths and undeterminables, either had mobility or were not in room of origin.

TABLE 6

DATA ON ROOM OF ORIGIN/MOBILITY

COVERING 117 FIRES WITH FATALITIES

Number of Victims			171
Less Victims in:			
Apparel Fires	8		
Explosions	2		
Undeterminable Room of Origin and Mobility	8		
Undeterminable Mobility	3		
		SUBTOTAL	21
Number of Victims with Mobility and Origin			150
Victims in Room of Origin	38		
Less Victims with Mobility in Room of Origin Fatalities	30		
		SUBTOTAL	8
Total Victims with Mobility and Not in Room of Origin			142

$\frac{142}{150} \times 100 =$ 95% of victims either had mobility or were not in room of origin

VIII. ACKNOWLEDGMENT

The APL Fire Research Group gratefully acknowledges the cooperation and support of the numerous organizations and individuals that have been involved in this study, in particular Mr. James C. Robertson, Maryland State Fire Marshal and his staff, Dr. Russell S. Fisher, Chief Medical Examiner of Maryland and his staff, Dr. Yale Caplan, Chief Toxicologist for Maryland Medical Examiner's Office; Chief Thomas Burke, Battalion Chief Frank Little and the Baltimore City Fire Investigation Bureau staff; Chief Burton Johnson and Battalion Chief John Breen and the Washington, D. C., Fire Investigation Bureau staff; and the staffs of Montgomery County, Prince George's County, Anne Arundel County and Baltimore County Fire Investigation Bureaus.

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ENCLOSURE 1

CASE REPORT NO. FPS-1

FIRE CASUALTY DATA SUMMARY

Case Data:

Case No: FPS-1 Fatality: Single _____ Multiple X

Date of Fire: 7/18/76 Fire Alarm Time: 5:18AM

F.D. Arrival Time: 5:23AM

Location of Fire:

City: _____ County: Montgomery (Urban) State: Maryland

Casualty Data:

Number of Casualties: 3

	Fatal	Smoke or Gas	Burn	Other
Civilians:	2		1	
Firemen:				

Contributing Factors in Fatalities:

Handicapped _____ Asleep X Reentrering _____

Medicated _____ Blocked Exits _____ Panic _____

Intoxicated X Trapped X Other _____

Number of Escapees: 1

Occupancy:

Type Unit Where Fire Occurred:

House X Motel _____ Rooming House _____

Apartment _____ Mobile Home _____ Home for Aged _____

Hotel _____ Vehicle _____ Other _____

Type Construction: Single family Brick, 2-story, detached

Building Materials:

Exterior: Brick: asphalt shingle roof

Interior: Wood paneling in room of origin

Type Heating System: Hot air

Fire Data:

No. of Floors: 2 Fire Floor: 1 Victim Floor: 2

Location of Victim: One in bed; second at top of stairs to another sleeping area.

Floor Plan Attached: Yes

Room of Origin: Living room

Ignition Source: Smoking material

Item Initially Ignited: Sofa

Detection — Protection Systems:

Type of Automatic Fire Detector Installed:

Heat _____ Heat and Smoke/Gas _____

Smoke/Gas _____ None X Unknown _____

Type of Automatic Fire Protection System Installed: None

Remarks:

See attached report.

EVALUATION

1. Due to the nature of construction of this single-family dwelling, minimum coverage with fire detectors would be two smoke detectors. There were two separate second floor sleeping areas which were not connected and access was by way of two separate stairways. The construction would permit installation of a detector at an appropriate location to cover the sleeping areas adequately.

2. The minimum coverage as noted above would have provided ample warning time for the occupants to effect an escape. Even though one occupant was heavily intoxicated, the time factor which seems to have been available to detect during the smoldering phase is estimated to be 30-45 minutes. This time would have permitted the other occupants time to help alert the intoxicated occupant. It is also possible that the intoxicated occupant would have been awakened by the detector alarms.

3. The time factor involved would also have permitted an earlier alarm to the Fire Department, resulting in less property damage. If the alarm was automatically sent to alarm headquarters, there is no doubt that there would have been sufficient time to minimize life and property loss.

4. An automatic suppression system in this home, installed in the room of origin, would have limited the fire spread significantly and probably would have limited the fire to the sofa in which the fire originated.

CASUALTY INFORMATION

No. 1 - Fatal - W-F-46 COHb 78%; Alcohol .24%

1. This female victim was found in bed in the bedroom directly above the room of origin of the fire. The bedroom was part of an addition to the original home. (See attached sketches BEDROOM #1)

2. This victim had a blood alcohol level of .24% which must be considered a highly intoxicating level.

3. The victim was known to be in the room of origin with the other two occupants from approximately 3:00 AM to 4:00 AM at which time all occupants retired to their respective bedrooms.

4. No evidence of medication or other drugs was found.

5. It was assumed that this victim did not attempt an escape.

No. 2 - Fatal - W-M-56 COHb 79%; Alcohol .04%

1. This male victim was found at the head of the stairway leading to the bedroom areas in the original portion of the house. He was found face down on an upper-level landing with his feet still in the hallway. (See attached sketches)

2. This victim had a blood alcohol level of .04% which is not considered to be a significant level.

3. This victim was known to be in the room of origin with the other two occupants from approximately 3:00 AM to 4:00 AM, at which time all occupants retired to their respective bedrooms.

4. No evidence of medication or other drugs was found.

5. It is assumed that this victim was alerted to the fire situation and became incapacitated while attempting to escape.

No.3 - Injury - W-M-23

1. This casualty incurred burn injuries to his feet and hands while escaping the fire. He exited through his bedroom window onto the roof of the involved section of the house. At the time of

escape, the stairway exit and bedroom areas were fully charged with thick smoke. The fire was also well advanced such that the roof was sufficiently hot to cause the burn injuries.

2. No blood alcohol readings are available for this casualty.

3. See Item 3 of the previous casualties.

4. No available information about drugs or medication.

5. This casualty was alerted by the "smell of smoke" and finding his primary means of egress "blocked" by smoke, he escaped through his bedroom window, calling for help.

SCENARIO

A. Summary

I. The fire occurred in a single-family, two-story, detached brick and wood/frame house in an affluent section of Montgomery County, Maryland. The house was approximately twenty-five years old with an addition to the house providing a living room and second floor bedroom area. The house was in an urban type setting with approximately twenty feet between adjacent houses.

II. It is known that the occupants were in the living room of the house, smoking and talking from approximately 3:00 AM to 4:00 AM, at which time they all went to bed.

III. The fire was detected at approximately 5:10 AM by at least one of the occupants and escape attempts were made by two of them, with one succeeding. At this time, the fire was well involved and the house fully charged with heavy smoke.

IV. The alarm was received for dispatch at 5:18 AM. The survivor, while escaping, was yelling for help, so the first alarm type of call was routed through the police by neighbors who thought there was some other type of trouble. A short period of time separated the first call from a call for fire department aid. The first apparatus arrived on the scene at 5:23 AM.

V. On arrival, the room of origin (living room) was fully involved with flames coming out all windows. The fire had extended to the second floor bedroom area and flames were coming out the bedroom window on the side of the house.

VI. The ignition was assumed to be caused by a misplaced cigarette on the living room sofa.

VII. Once ignition was attained, the 1/4" wood wall paneling (only wall covering in this section of the house) was ignited as well as the styrofoam ceiling panels.

VIII. This home had several means of egress from the bedrooms in the original part of the house. The normal means of exit would be via the stairway to the first floor. The side bedroom windows provided emergency exits onto sloping roof with only a three to four foot frop from the window. The rear section of the house then permitted a short drop to an outside porch deck while the front section provided a short drop to ground level. On the first floor there were two outside door exits as well as windows. One of the door exits would have required going through a portion of the room of origin. Egress from the bedroom in the added section of the house was via either a stairway down to the living room or a single bedroom window on the side of the house, with a 15-20 foot drop to the ground. The stairway came down directly into the room of origin.

B. Narrative

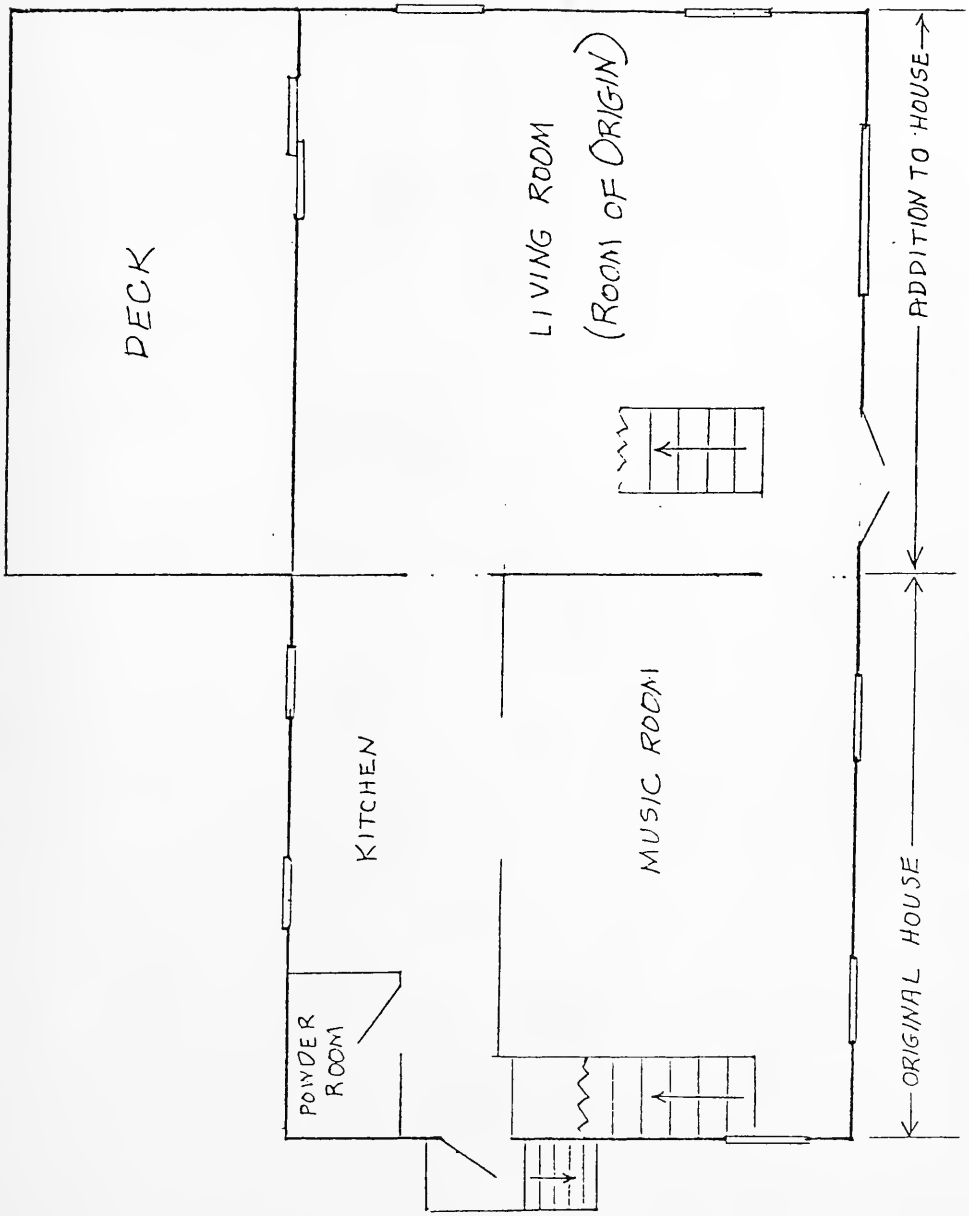
All three occupants of the involved home arrived home at approximately 3:00 AM and sat talking and smoking until approximately 4:00 AM. They all went to their respective bedrooms at 4:00 AM.

The residence where the fire occurred was a hybrid structure, that is, an addition containing a living room and porch deck on the first floor and a bedroom and storage room on the second floor had been built onto the original house. There was no connecting doorway between this bedroom and the other three bedrooms on the second floor of the original structure. The only access to the add-on bedroom was by way of a stairway from the add-on living room. However, a window in the side wall of the add-on bedroom could serve as a potential emergency exit (see three sketches for details).

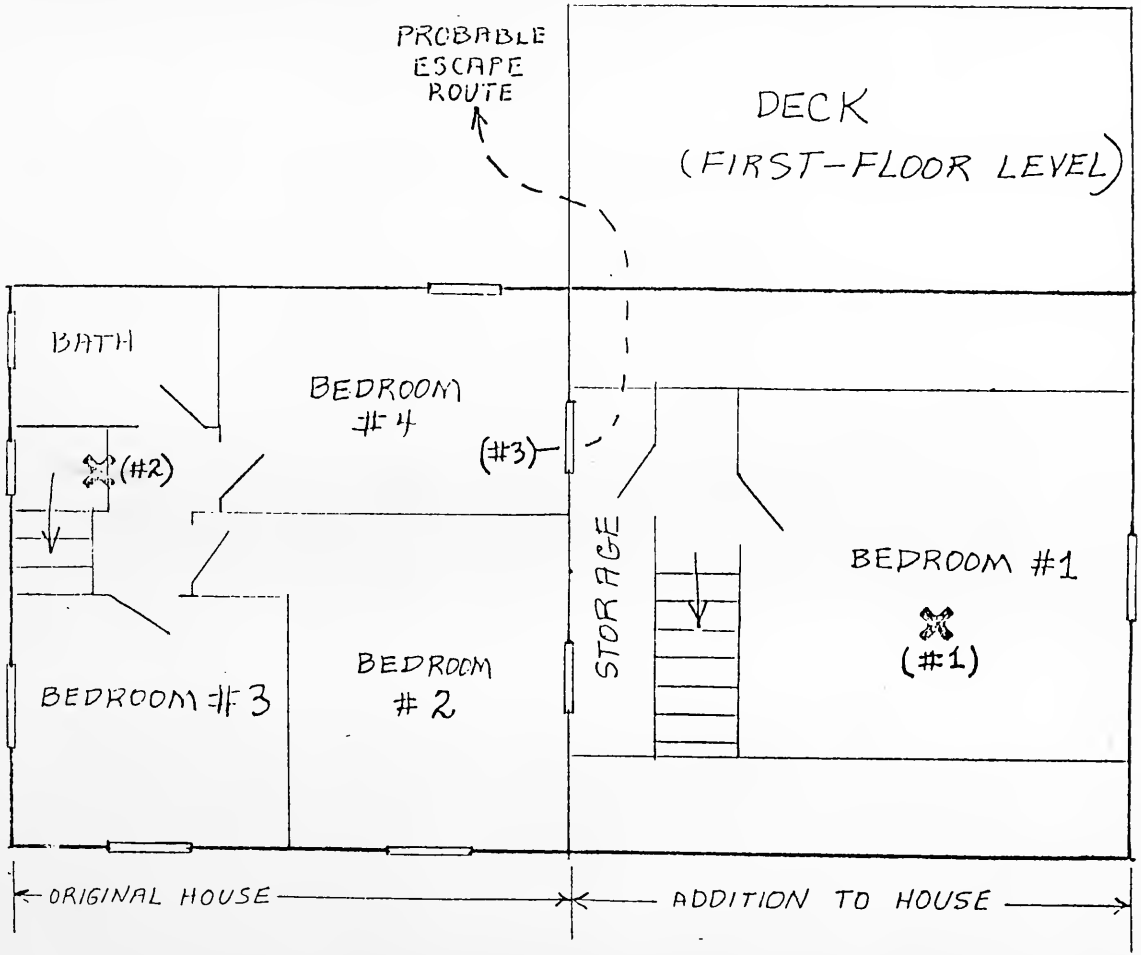
The room of origin was the add-on living room. The add-on living room and bedroom above were completely involved when the Fire Department arrived. The fire was quickly struck down before the flames reached the rooms of the original structure. However, all of the rooms, except one in the original house, received very heavy smoke damage and some heat damage. The inside of one of these bedrooms (#2) received virtually no smoke damage, this being attributed to the fact that the bedroom door was closed during the fire.

Information presently available indicates that the fire may have been smoldering for about one hour before significant flaming occurred. The occupants were reported to have returned home at 3:00 AM and conversed until about 4:00 AM when they retired to their bedrooms. At about 5:15 AM, a neighbor heard a call for help coming from the house and called the police first, but shortly thereafter called in a fire alarm when he saw the house in flames. (The alarm was received at 5:18 AM.)

Items considered to be involved in the ignition and spread of the fire were a sofa (initial item) and matching chair with polyurethane cushions and synthetic fiber covering. Wood wall paneling in the living room, with no other fire protective wall covering, added to the spread significantly, along with the styrofoam ceiling panels. The draperies for the room were consumed and most of the synthetic wall-to-wall carpeting was also consumed.

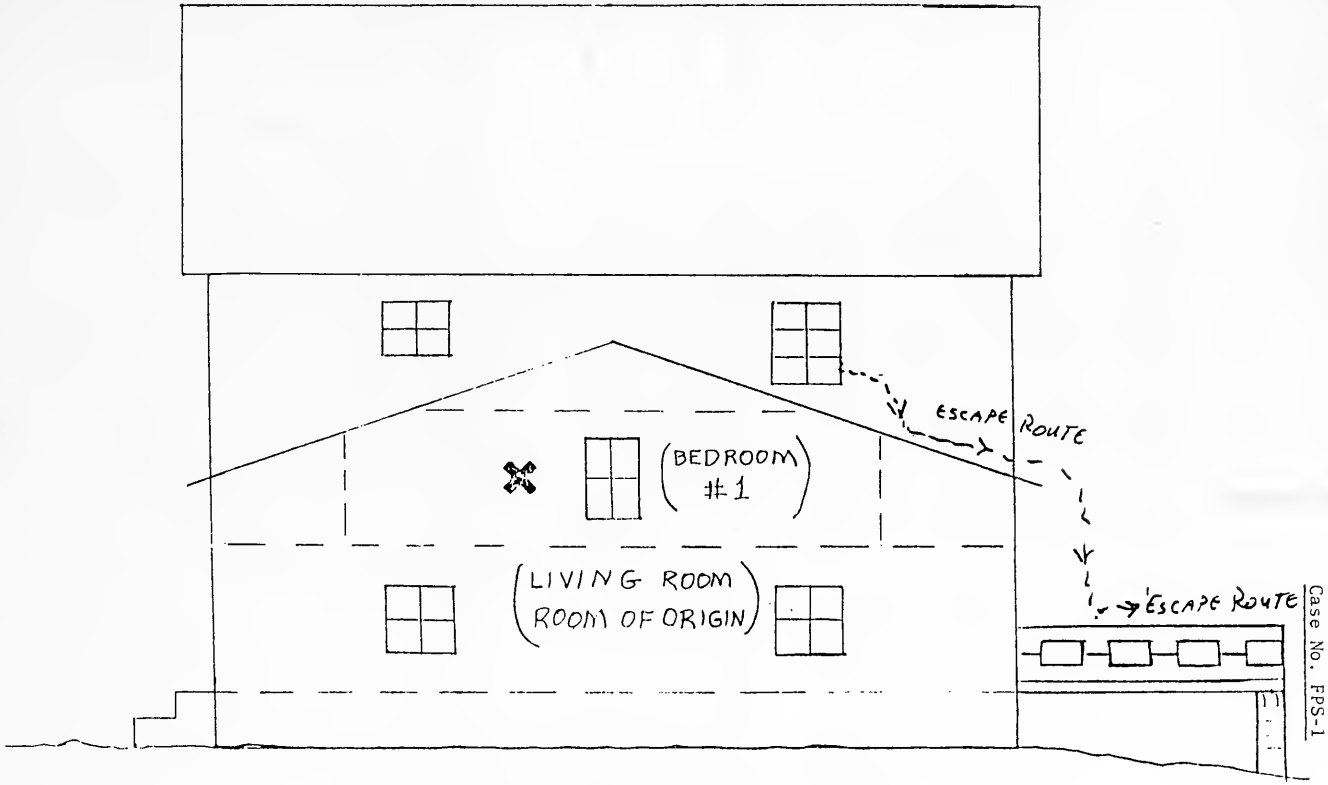


FLOOR PLAN - FIRST FLOOR



FLOOR PLAN SECOND-FLOOR (BEDROOM) LEVEL

✕ ~ LOCATION OF VICTIMS



ELEVATION~ LIVING ROOM SIDE

✕ ~ LOCATION OF VICTIM #1

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT
(Fires with at Least 1 Fatality)

Fire Information			Predicted Results with Installed Fire Protection System			
		Actual		Detector System (1) (2)	Suppression System (1)	Remote Alarm System * (1) (3)
Casualties	Deaths	2	Saved	1	2	2
			Prob. Saved	1		
			No			
	Injuries	1	Saved	1	1	1
			Prob. Saved			
			No			

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT

(Fires with at Least 1 Fatality)

Fire Information			Predicted Losses with Installed Fire Protection System		
		Actual	Detector System (1) (2) (3)	Suppression System (1)	Remote Alarm System (1)
Property Loss (Thousands) (of Dollars)	Building	25	5	2	5
	Contents	7.5	2	2	2
	Total	32.5	7	4	7

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

ENCLOSURE 2

CASE REPORT NO. FPS-28

FIRE CASUALTY DATA SUMMARY

Case Data:

Case No: FPS-28 Fatality: Single X Multiple ____

Date of Fire: 1-7-77 Fire Alarm Time: 04:15

Location of Fire: F.D. Arrival Time: 04:20

City: Hagerstown County: Washington State: Maryland

Casualty Data:

Number of Casualties: I

	Fatal	Smoke or Gas	Burn	Other
Civilians:	I	____	____	____
Firemen:	____	____	____	____

Contributing Factors in Fatalities:

Handicapped ____	Asleep X	Reentrering X
Medicated ____	Blocked Exits ____	Panic ____
Intoxicated ____	Trapped ____	Other ____

Number of Escapees: I

Occupancy:

Type Unit Where Fire Occurred:

House X	Motel ____	Rooming House ____
Apartment ____	Mobile Home ____	Home for Aged ____
Hotel ____	Vehicle ____	Other ____

Type Construction: Ranch style.

Building Materials:

Exterior: Stone and aluminum siding, wood shake shingles on roof.

Interior: Gypsum board walls and ceiling.

Type Heating System: Heat pump, circulating hot air.

Fire Data:

No. of Floors: I Fire Floor: I Victim Floor: I

Location of Victim: On floor in hallway from living room to side exit behind garage.

Floor Plan Attached: Yes

Room of Origin: Enclosed patio-porch outside living room.

Ignition Source: Faulty wiring in electric cord to heater.

Item Initially Ignited: Rug.

Detection — Protection Systems:

Type of Automatic Fire Detector Installed:

Heat ____	Heat and Smoke/Gas ____	
Smoke/Gas X(*)	None ____	Unknown ____

Type of Automatic Fire Protection System Installed: None

Remarks:

See details in attached report.

(*) Ionization type.

EVALUATION

1. Considering the arrangement of rooms in this single-family dwelling, minimum coverage with fire detectors would require one smoke detector located in the hallway outside the bedroom.

2. The above minimum coverage was provided in this house and did, in fact, provide sufficient warning for the two occupants to escape. The man and wife exited the house to safety. However, he forfeited his life when he re-entered the burning building to call the fire department. In this case, the smoke detector alarm was not instrumental in bringing the fire department to the scene earlier (the alarm was phoned in by a neighbor). Thus, it played no part in diminishing property damage.

3. If the detector had been provided with remote alarm capability, the fire department would probably have arrived many minutes earlier than they did. The property damage would probably have been significantly less. It is also probable that the earlier arrival of the firemen would have meant the difference in successfully reviving the victim or the knowledge of the remote alarm capability would have possibly kept the man outside.

4. An automatic fire suppression system in this house probably would have limited the fire to the room of origin. The resultant minimal damage would probably have been a little less than with the fire detector with remote alarm capability.

5. This case is a documentation of the importance of proper response of occupants in the fire situation when an alarm is sounded by a fire detector, namely, to escape at the first indication of fire as provided by the detector alarm and do not re-enter the fire scene.

CASUALTY INFORMATION

Fatal: W-M-66; COHb---45%; Alcohol---Negative

1. This male victim was found overcome on the floor of a hallway leading from the center of the house to a side exit behind the built-in garage.

2. Firemen removed the victim from the burning house and applied artificial respiration (CPR) for about a half hour. They managed to revive him but he subsequently died at the hospital a short time later.

3. The victim's blood showed a carboxyhemoglobin level of 45%. The CPR effort undoubtedly lowered the COHb from a higher initial level, possibly 50% or higher, down to the 45% level found in the post-mortem analysis.

4. No evidence of alcohol, medicine, or other drugs was found in the victim.

5. The victim and his wife were in fact alerted and "saved" by the smoke detector installed in the house. However, by choosing to re-enter the burning house to call the fire department, the victim forfeited his life.

6. The probable cause of death was asphyxiation by carbon monoxide poisoning.

SCENARIO

A. SUMMARY

I. This fire occurred in a modern, ranch-style frame house located in a residential section of Washington County near Hagerstown, Maryland.

II. The fire resulted in one fatality who at one time had escaped the fire uninjured but who was fatally overcome when he re-entered the burning house to call the fire department. The victim's wife had escaped with him but she remained safe outside.

III. The room of origin was an enclosed porch located off the living room. The probable ignition source was failure of undersized wiring added to the electric cord of a space heater. The item first ignited was apparently a rug on the porch floor.

IV. The fire completely involved the enclosed porch and the living room. There was serious heat and smoke damage, more or less, throughout the rest of the house.

V. An alarm sounded by an ionization-type smoke detector installed in a hallway outside the bedroom aroused the victim and his wife from their sleep. They escaped outside.

VI. However, the victim re-entered the burning house to call the fire department. The receiver was later found off the telephone. Realizing the danger of his situation, the victim apparently attempted to escape again by a side door but failed.

VII. The fire department, arriving on the scene five minutes after an alarm was phoned in by a neighbor, found the victim overcome on the floor of the hallway leading to the side exit. Firemen got the victim out and administered artificial respiration (CPR). The victim was revived but he subsequently died at the hospital a little later.

B. NARRATIVE

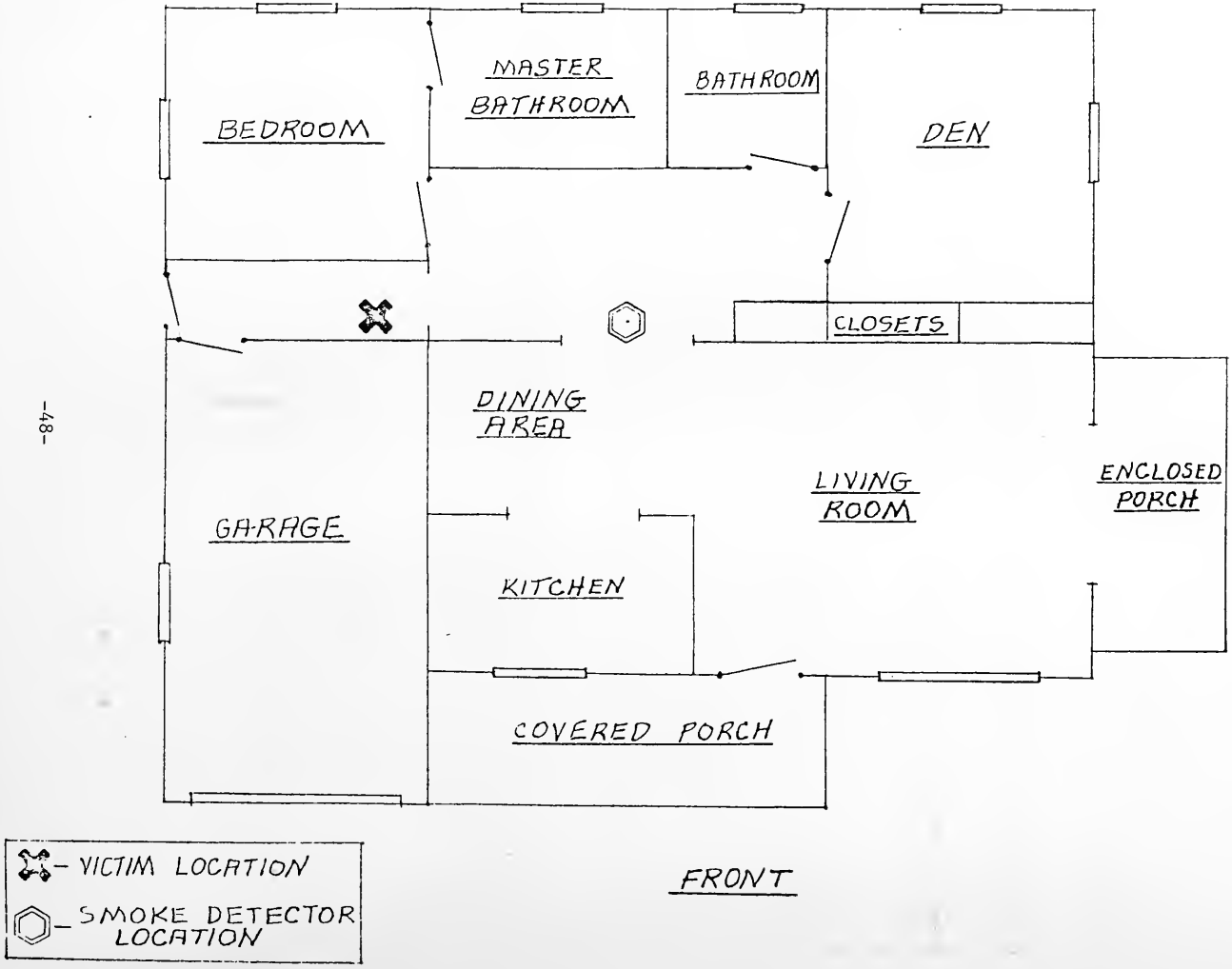
The residence where this fire occurred was a modern, ranch-style, frame house located in a residential section of Washington County, Maryland. The arrangement of rooms in the house is shown in the enclosed sketch. An ionization type smoke detector was installed in an appropriate location in the house.

The fire started in the enclosed patio-porch where a space heater of the self-contained, water-electrical type was plugged into an outlet. The heater had been recently removed from storage and installed on the porch two days prior to the fire. The heater cord was modified by splicing ordinary electric wires on the end of the existing cord in order to make the connection to the outlet on the porch. The wiring to the heater was considered to be the source of ignition of the fire.

During the night while the victim and his wife were asleep in their bedroom, the smoke detector alarm went off and aroused them from their sleep. The wife reported that, at the time they were awakened by the detector alarm, no smoke was visible or detectable in their bedroom. She reported that, on investigation, they saw fire in the room of origin but the room was not as yet completely involved. However, shortly thereafter, an "explosion" (as she described it) occurred and the fire involved the whole porch and began to spread into the house. The victim, his wife, and their dog then exited the house, with the man evidently having to force his wife out in her nightgown. After getting his wife out, the victim re-entered the house to call the fire department. The receiver was later found off the telephone. Realizing the danger of his situation, the victim apparently attempted to escape again by a side door but failed.

The fire department, arriving on the scene at 04:20 within five minutes of receipt of the alarm, got the victim out and administered CPR. The victim was revived but he subsequently died at the hospital a short time later. This victim and his wife were in fact "saved" by the smoke detector, but by choosing to re-enter the burning house, the man forfeited his life. He could have gone to a neighbors house to call the fire department. In fact, it was one of the neighbors who reported the fire.

This house had a burglar alarm system installed and connected to a Protective Services office in the City of Hagerstown. If the alarm were triggered, a signal would show up in that office and the police would be notified. It was reported that the owner had intended to connect the smoke detector in the house into the same system, thereby providing the detector, in a sense, with remote alarm capability. That hook-up, of course, was never made.


BEDROOM
MASTER BATHROOM
BATHROOM
DEN
CLOSETS
DINING AREA
LIVING ROOM
ENCLOSED PORCH
GARAGE
KITCHEN
COVERED PORCH
FRONT
- VICTIM LOCATION
- SMOKE DETECTOR LOCATION

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT
(Fires with at Least 1 Fatality)

Fire Information			Predicted Results with Installed Fire Protection System			
		Actual		Detector System (1)(2)	Suppression System (1)	Remote Alarm System (1)(3)
Casualties	Deaths	1	Saved	1	1	1
			Prob. Saved			
			No			
	Injuries	0	Saved			
			Prob. Saved			
			No			

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT

(Fires with at Least 1 Fatality)

Fire Information			Predicted Losses with Installed Fire Protection System		
		Actual	Detector System (1)(2)	Suppression System (1)	Remote Alarm System (1)(3)
Property Loss (Thousands) (of Dollars)	Building	8	8	3	4
	Contents	8	8	3	3
	Total	16	16	6	7

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

ENCLOSURE 3

CASE REPORT NO. FPS-73

FIRE CASUALTY DATA SUMMARY

Case Data:

Case No: FPS-73 Fatality: Single X Multiple _____

Date of Fire: 6/29/77 Fire Alarm Time: 05:59

Location of Fire: F.D. Arrival Time: 06:06

City: _____ County: Calvert (Rural) State: Maryland

Casualty Data:

Number of Casualties: 7

	Fatal	Smoke or Gas	Burn	Other
Civilians:	1	5	1	
Firemen:				

Contributing Factors in Fatalities:

Handicapped _____ Asleep _____ Reentering _____

Medicated _____ Blocked Exits _____ Panic _____

Intoxicated _____ Trapped _____ Other Aged

Number of Escapees: 8

Occupancy:

Type Unit Where Fire Occurred:

House _____ Motel _____ Rooming House _____

Apartment _____ Mobile Home _____ Home for Aged X

Hotel _____ Vehicle _____ Other _____

Type Construction: Frame, ranch-style, one floor and basement.

Building Materials:

Exterior: Aluminum siding, cinder block foundation

Interior: Wood paneled walls

Type Heating System: Electric baseboard

Fire Data:

No. of Floors: 2(*) Fire Floor: basement Victim Floor: basement

Location of Victim: On floor beside bed in room of origin

Floor Plan Attached: Yes

Room of Origin: Patient's bedroom

Ignition Source: Electrical malfunction in fan on top of dresser.

Item Initially Ignited: Combustible item on top of dresser

Detection – Protection Systems:

Type of Automatic Fire Detector Installed:

Heat _____ Heat and Smoke/Gas _____

Smoke/Gas X None _____ Unknown _____

Type of Automatic Fire Protection System Installed: System included photo-electric-type smoke detectors, automatic internal alarm, remote alarm capability, and manual pull station.

Remarks:

(*) First Floor and basement.

EVALUATION

1. Minimum coverage with fire detectors in this Domicilary Care Home for the aged would require three smoke detectors, two of them located outside the end bedrooms on the basement level and one located in the hall outside the bedrooms on the first floor level.

2. The basement level of this home was equipped with a fire detection system which included a photoelectric-type smoke detector in each of the three patient rooms, an automatic internal fire alarm triggered either by the detectors or by a manual-pull alarm station, and a remote-alarm transmitter which automatically sends the alarm to the fire station over telephone circuits when the system is triggered. The system was connected to photoelectric smoke detectors only in the basement where patients normally roomed. A separate ionization detector (not in the system) was mounted in the first floor hallway outside the bedrooms.

3. In this case the detector system was considered effective to the extent that it provided sufficient early warning time for 7 of the 8 occupants of the Home to survive the fire, although one of the seven was seriously burned. The early arrival of the fire department was an important factor in limiting the fire damage to an estimated 15 percent of the value of the home. It is believed there would have been a number of additional deaths and greater fire damage if there had been no detector system in the home

4. However, based on the scenario and sequence of events reconstructed from investigation of the fire, it would appear that the detector system should have alarmed even sooner than it did. Within an estimated one minute of the time that the owner (alerted only seconds before by the internal alarm) opened the door leading from the first floor to the basement, the ionization-type smoke detector in the first floor hallway sounded its alarm. Apparently, about 1½ to 2 minutes before the ionization-type detector alarmed, the photoelectric-type detector in the room of origin had not triggered the internal alarm even though the smoke must have been somewhat heavy there.

5. The remote alarm capability of the fire detection system in this home probably brought the fire department to the scene at least 3 minutes sooner than if the owner of the home had telephoned in the alarm. It is believed that a 3 minute later arrival of the fire department in answer to a telephoned alarm would have resulted in some increase in fire damage but probably not a significant increase. However, a later arrival could have affected the number of fatalities. With the remote alarm, the owner had the assistance of a volunteer fireman in evacuating patients from their rooms. A 3 minute delay in the arrival of the volunteer might have meant that both occupants of the room of origin would have been lost instead of just one. Therefore, the remote alarm was probably instrumental in diminishing fire damage somewhat and in the saving of at least one life.

6. It is believed that an automatic fire suppression system in the room of origin would have significantly limited the fire damage. The fire should have been quenched before it had progressed too far in the flaming stage which would have meant the occupants of the room would have been subjected to less heat and toxic combustion products and, therefore, they probably would have survived.

CASUALTY INFORMATION

No. 1: FATAL: W-F-76; COHb---5%; Alchohol---Negative

1. This 76 year old female was found on the floor beside her bed in the room of origin after the fire was struck down.

2. She was transported to the hospital where she was declared dead on arrival.

3. Carboxyhemoglobin level in the victim's blood was found to be a very low 5% which is not even an incapacitating level.

4. Establishing the cause of death must await the autopsy report.

No. 2: INJURY: W-F-70

1. This 70 year old female was in her bed in the room of origin when the fire was discovered.

2. She was rescued from her bed by the owner and a volunteer fireman.

3. She was sent to the hospital where she was listed in serious condition with 2nd and 3rd degree burns over 50% of her body.

Nos. 3 through 7: INJURIES: W-F-92; W-F-85; W-M-85; W-F-82; W-M-74

These patients who were rescued from the burning home were admitted to the hospital where they were treated for smoke inhalation.

SCENARIO

A. SUMMARY

I. This fire occurred in a domicilary care home located in a rural section of Calvert County, Maryland. The basement which was devoted to rooms for ambulatory aged patients had a fire detection system with an automatic internal alarm and remote alarm capability into the county fire alarm system.

II. The fire resulted in one fatality and six injuries. Eight occupants escaped or were rescued, including a man and wife who owned the home and the six patients who were injured.

III. The room of origin was a bedroom occupied by two of the patients. The ignition source apparently was an electrical malfunction in a ventilating fan that was sitting on top of a wooden dresser. The item first ignited was probably a combustible item, like a scarf, that was on top of the dresser.

IV. The fire burned through the top of the dresser and ignited the contents of the dresser. The fire carried up to the wood paneling on the wall behind the dresser and ignited it despite the fact that the panels had been painted with a "fire-retarding" varnich. Most of the paneling in the room of origin was burned away. The fire spread upward past the non-flammable ceiling tile and charred some of the rafters in the room of origin. When the glass in the exit door was broken during rescue attempts, the fire carried up the outside of the back of the building and into the attic space where some stored items were ignited.

V. The alarm was automatically transmitted to the county volunteer fire department at 05:59 hour when the fire detection system was triggered by smoke from the fire. The first fire apparatus arrived on the scene from the fire station 5 miles away at 06:06. When firemen arrived, the room of origin was fully involved and flames were shooting out of the exit and up the outside wall towards the attic.

VI. Firemen assisted in the evacuation of the patients and struck down the fire, after which they found one of the occupants of the room of origin on the floor near her bed. She was sent to the hospital where shw was declared dead on arrival.

B. NARRATIVE

This fire occurred in a Domicilary Care Home for the aged in a rural section oc Calvert County, Maryland. This type of home has the lowest level of requirements for homes for the aged since it is required that patients be ambulatory. The arrangement of rooms in this home is shown in the attached sketches. Patients occupied three rooms on the basement level and one room on the first floor.

The basement level of the home was equipped with a fire detection system that had remote alarm capability into the county fire alarm system as well as an internal fire alarm. The system included a photoelectric type smoke detector in each of the patients' rooms, a fire alarm bell in the basement recreation room outside the patients' rooms. On the first floor where the owner-operators lived, there was a second alarm bell, a manual pull station, a remote alarm transmitter, and a central control panel. The first floor of the home was not tied into the above system but a single ionization-type smoke detector was mounted in the hallway outside the bedrooms there.

On the day of the fire, the man and wife who owned and operated the home were asleep in their bedroom on the first floor. Just before 6AM they were awakened by the internal fire alarm bell outside their bedroom. They got up and the husband went down the hall and opened the door to the stairway that led down to the basement. Smoke coming up the steps drove him back and he shut the door. Shortly thereafter the ionization-type smoke detector in the first floor hallway sounded its alarm.

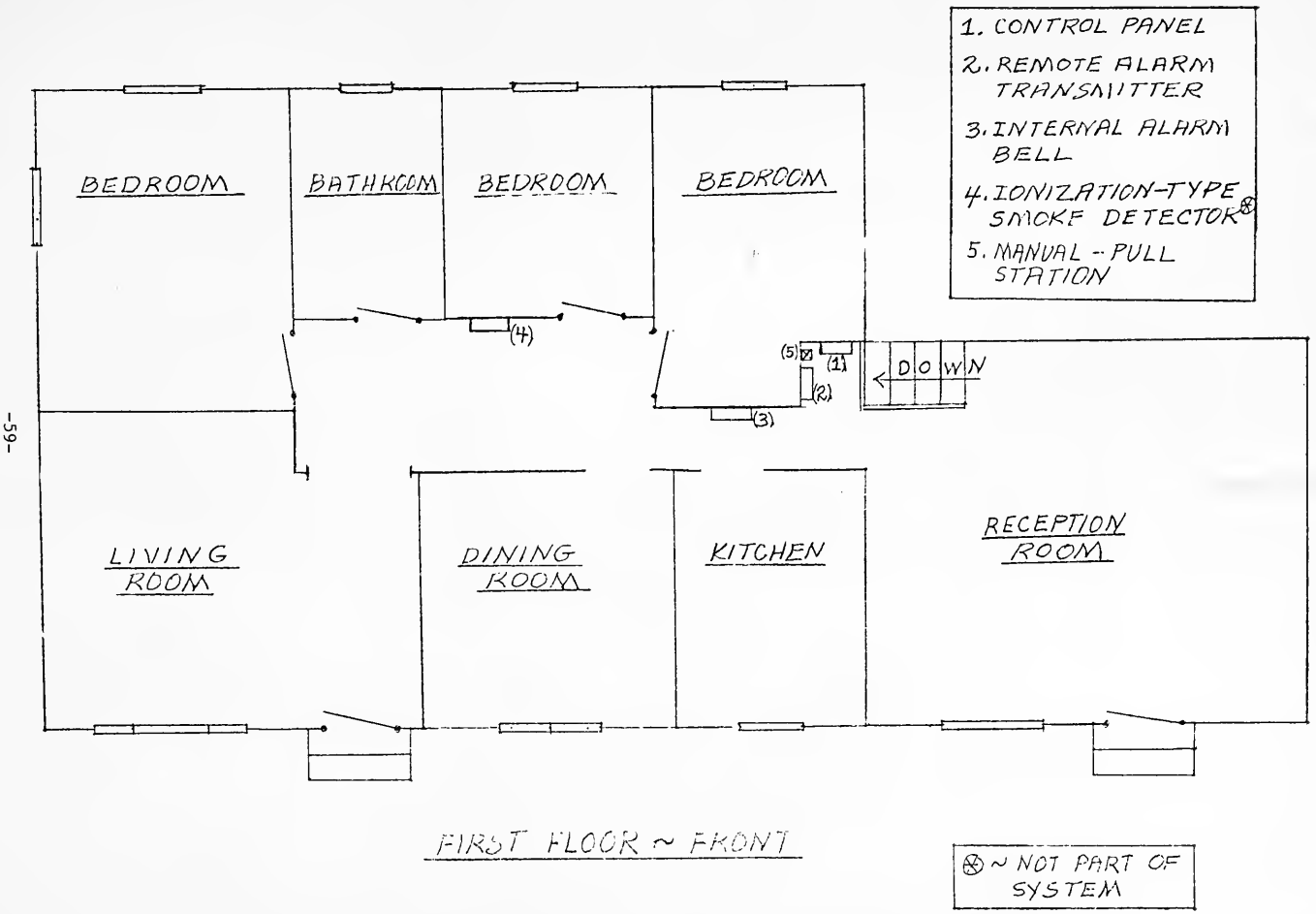
The husband ran outside to the basement level in the back of the house where he saw smoke coming out of the room of origin at one corner of the house. The exit doors for the three patient rooms were locked on the inside. Meanwhile a volunteer fireman heard about the fire on his radio which monitors such calls. He went to the scene of the fire where he met the owner in the back of the house. The two of them broke the glass in the door to the room of origin, opened the door, and managed to get one (casualty No. 2) of the two occupants outside. Before the window in the door was broken, the fire was subdued by the smoke was thick in the room of origin. When the door was opened, a flashover occurred shortly thereafter and the glass window blew out of the adjacent bathroom. When they attempted to get the second patient out of the room of origin, they could not get in the door because of the flames and smoke.

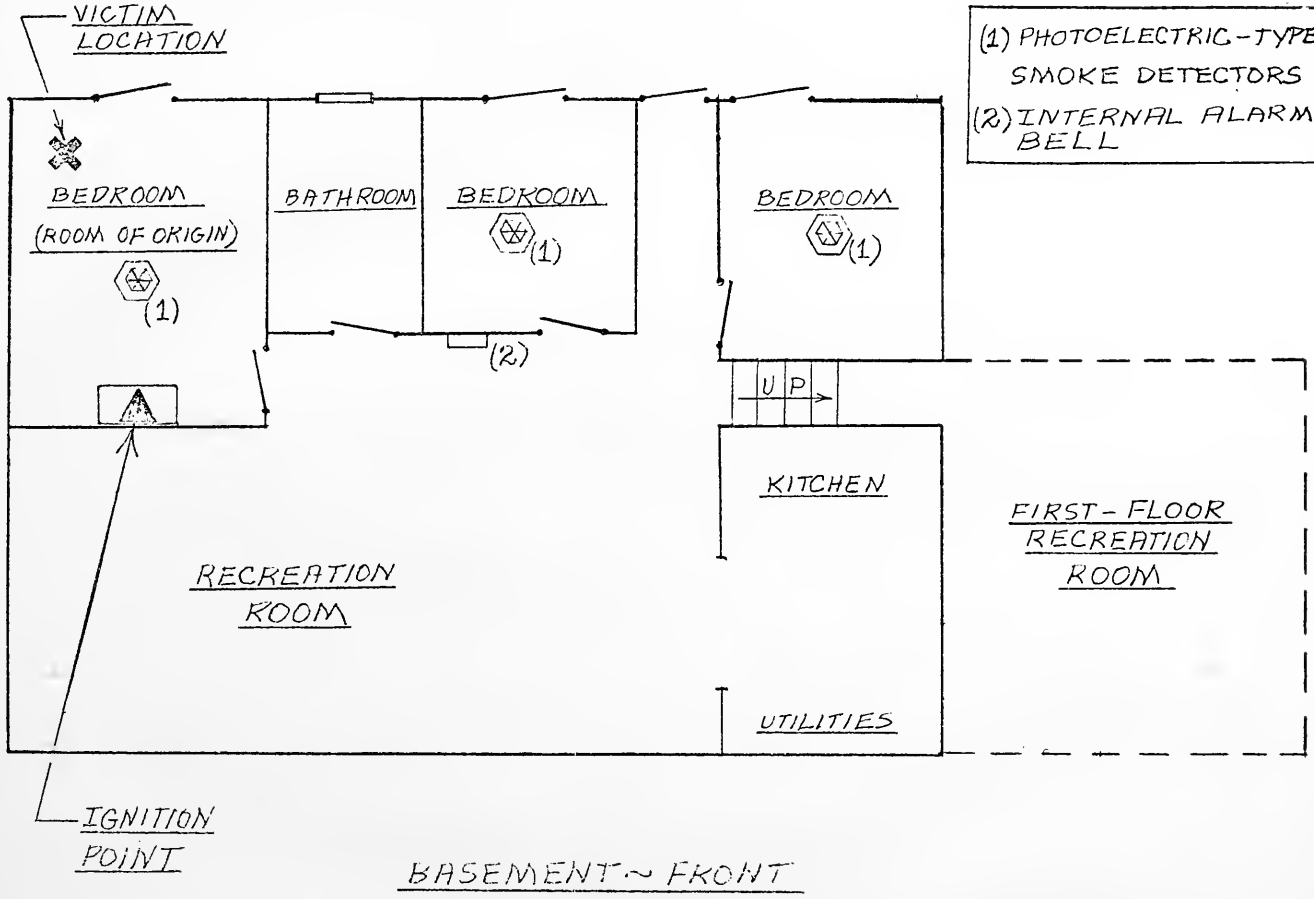
One of the two men then went to the middle room, broke the glass in the door, opened it, and led one of the two patients outside. The second man went to the room farthest from the room of origin and led the sole occupant out the door to safety. It was noted by investigators that the screen door in this room opened inward rather than outward. This same condition also existed in the other rooms.

When the internal fire alarm sounded in the home, a remote alarm was also automatically transmitted to the fire department. The alarm was received for dispatch at 05:59 hour and the first apparatus arrived from the station house 5 miles away at 06:06. One fireman led the second occupant out of the basement middle room. Other firemen assisted the wife in bringing two male patients out of the first floor bedroom which they were occupying.

When the fire was struck down, firemen found the second occupant of the room of origin on the floor near her bed. She was sent to the hospital where she was declared dead on arrival. The other occupant of the room of origin was also transported to the hospital where she was listed in serious condition with 2nd and 3rd degree burns over 50% of her body. Five additional occupants were treated at the hospital for smoke inhalation.

Investigation after the fire concluded that the probable source of ignition of the fire was an electrical malfunction in a ventilating fan that was sitting on the top of a dresser in the room of origin. The fan had been operating continuously since 11 PM on the evening before the fire occurred. Either the fan moter overheated because of that or a scarf under the fan may have become lodged in the blades and stopped the motor, thereby causing it to overheat. The resulting fire burned through the top of the wooden dresser and ignited some of the contents. The fire carried back to the wood paneling on the wall behind the dresser and ignited it despite the fact that the panels had been painted with a "fire-retarding" varnish. Most of the paneling in the room of origin was burned away. The fire spread upward past the non-flammable ceiling tile and charred some of the rafters in the room of origin. When the glass in the exit door of the room of origin was broken, the fire carried up the outside of the back of the building into the attic space where some stored items were ignited. The basement bathroom and recreation room were damaged by heat and smoke, but not too seriously. There was virtually no smoke damage in the other basement rooms nor in the first floor rooms.


1. CONTROL PANEL
2. REMOTE ALARM TRANSMITTER
3. INTERNAL ALARM BELL
4. IONIZATION-TYPE SMOKE DETECTOR ⊗
5. MANUAL -- PULL STATION
BEDROOM
BATHROOM
BEDROOM
BEDROOM
(4)
(5)
(1)
(2)
(3)
DOWN
LIVING ROOM
DINING ROOM
KITCHEN
RECEPTION ROOM
FIRST FLOOR ~ FRONT
⊗ ~ NOT PART OF SYSTEM



BASEMENT - FRONT

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT
(Fires with at Least 1 Fatality)

Fire Information			Predicted Results with Installed Fire Protection System			
		Actual		Detector System (1)(2)	Suppression System (1)	Remote Alarm System (1)(3)
Casualties	Deaths	1	Saved		1	
			Prob. Saved			
			No	1		1
	Injuries	6	Saved		4	
			Prob. Saved			
			No	6	2	6

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant dependant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

APL/JHU

ESTIMATE OF FIRE PROTECTION SYSTEMS' IMPACT

(Fires with at Least 1 Fatality)

Fire Information			Predicted Losses with Installed Fire Protection System		
		Actual	Detector System (1)(2)	Suppression System (1)	Remote Alarm System (1)(3)
Property Loss (Thousands) (of Dollars)	Building	20	20	5	20
	Contents	7	7	3	7
	Total	27	27	8	27

(1) Assumes proper occupant reaction and an effective system.

(2) The numbers shown for the detector system are more "occupant depandant" than the numbers shown for either the remote alarm system or the suppression system. Detectors must be properly placed, installed, maintained and tested. Occupant must have escape plan.

(3) One death on boat - removed from count since remote alarm system not applicable.

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